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17 July 1961

STAFF STUDY CRITIQUE ON MINIMUM IMAGE INTERPRETATION
PREPARED BY SPECIAL PROJECTS DIVISION OF DMJM

The concept of Minimum Image Interpretation is basic to photographic interpretation of small scale photography and the paper should be expanded into a study of the diagnostic features of various types of installations for training and ID purposes to be used as check-off lists in operational exercises. However there are some errors in the paper in its draft form.

Paragraph 1 of A1 Discussion contrast usually varies inversely with resolution and smaller scale.

Paragraph 2 of A1 Discussion Better describes Ops Support in proper context and differentiate between contribution of PI detailed report and other source material. (where and what to look for).

Paragraph 3 Can expand list to include location/function orientation, etc.

Section D, paragraph 2 Diagnostic features are usually derived from PI Detailed Reports and analysis of large scale photography or other inputs such as engineering diagrams, flow patterns. For

(Was this prepared in support of SEC?
If not, at whose direction?)

the most part the only complex things that can be described on minimum detail photography are those things which have been previously described, analyzed and synthesized on large scale materials.

PART II CRITIQUE ON AUTOMATIC HANDLING SYSTEMS
 REQUIREMENT FOR PIC

The ultimate image and mirror image categories are not well identified and are imaginary perhaps because everything that we have learned seems to negate these hypothesis. The eye is very limited in resolution and sensitivity when compared with the photograph/camera system and the brain has a poor retentive memory for detail. The mirror image on the other hand has the optical property of doubling the objective distance making it less desirable than the direct view. (This is taken from the context of the following paper.)

There are few criticisms of the rest of the paper except that it is implied that the scanning function of PI requires as much or more quality than detailed analysis and of course this is not the case.

PART III MIRROR IMAGE QUALITY CONCEPT

A satellite mirror would need to be placed at 22,240 miles from the earth and observing this reflective surface under ideal theoretical conditions with the 200" Mt. Palomar telescope would give a ground object size for detection of >1500' on a side.



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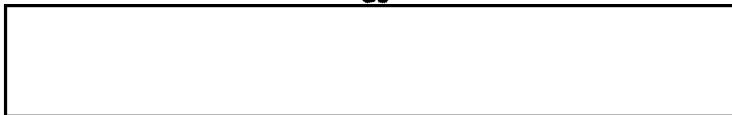
for Sid:

**FAMILIARIZATION OF
PHOTO INTERPRETATION BY
MINIMUM IMAGE INTERPRETATION**

Prepared By

Special Projects Division

of



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1. INTRODUCTION

Usually higher image quality handling requires a higher priced handling system. For economic reasons, it is necessary to determine the minimum image quality acceptable with respect to the functional applications of the PIC.

Where lower levels of image qualities are accepted for performing certain functions, it may be uneconomical to employ the use of a higher level image quality film handling system in that area. It must be remembered that the minimum image quality required for performing various functions is variable. The minimum image quality required may, in many instances, be of an extremely high nature.

This report will lay a basis for determining minimum image quality necessary for performing various PIC functions and, in turn, will dictate part of the automatic handling system requirements.

CONCLUSION

A. Familiarization of Photo Interpretation

1. Minimum Image Interpretation

Conventional interpretation techniques are based primarily on stereoscopic viewing of photography which may contain an almost infinite amount of detail. The interpreter uses identification clues that characterize installation components which, in turn, allow him to identify and describe the installation. These components are frequently very small, have high contrast, have significant height, etc. These types of components may or may not be recorded on small scale photography, thereby limiting their use as universally applicable clues for identification. It is, therefore, necessary to utilize unique and characteristic clues which have a high probability of being recorded on small scale photography. The minimum image concept is a method of determining and using these components, patterns, and associations which are characteristic of and unique for specific types of installations and which have a high probability of being available to the interpreter from small scale photography.

The task of determining the minimum required features for a particular target type is called "operations support". The name, operations support, is derived from the fact that this operation can be accomplished prior to the acquisition of small scale photography. The first step is to collect conventional scale photographs of a large representative sample of that type installation. This sample should include as much variety as possible, including different sizes and complexities of installations, various environments, countries, seasons, etc. The greater the variety of examples studied, the more certain the compiler will be that he is including all significant aspects of that type of installation.

The next step is to determine if the largest feature is unique and characteristic of the installation and if it has sufficient contrast to be recorded on small scale photography. If it satisfies these requirements, it is

the minimum imagery required for identification. If not, it is necessary to determine what other larger, bright object must be added to the first to provide identification. In most cases, it will be necessary to proceed down the line from the largest object and/or the object with the highest contrast, until a combination is found which is unique and characteristic and also will be recorded on small scale photography. Unique and characteristic means, in effect, that items or combinations of items, patterns and associations, are truly representative of the installation but do not occur in the same manner in other installations, i. e., a roundhouse is both characteristic and unique to railroad repair installations - no other industries have them. There are undoubtedly certain types of installations where only small items are the minimum required identification clues, in which case, extremely good resolution is required. The concept, however, is to determine identification clues which will impose the least resolution requirements on the photo acquisition system.

The technique of using these gross, unique, and characteristic features for identification of an installation is the subject of the following section; however, to make the section fully comprehensible, it is first necessary to define three terms: detection, recognition, and identification.

- a. Detection is the lowest level of interpretability, where the mere presence of an item is sensed, but the shape and/or identity is not necessarily determinable. Detectability is not a function of the photographic system alone, but is dependent upon the combined operation of the system, plus the observer. In other words a detectable item must have size characteristics compatible with the ground resolution parameters of the system and the system must record the items with sufficient contrast to render it discernible from its background by the human eye.
- b. Recognition is the level of interpretability where the interpreter can determine the true shape of the plan view of an item, i. e., circular, oval, square, etc. Recognition of an item is affected

by three of the item's characteristics: its minimum dimension, its contrast, and its aspect ratio (aspect ratio is defined as the length of an item divided by its width).

- c. Identification is the level of interpretability whereby a trained interpreter can apply a descriptive functional name to an item, i. e., building, fabrication building, railroad, river, earth scar, etc. Identification is the sum of the image content of the photography plus the training and experience of the interpreter.

2. Interpretation Techniques

The basic premise of the interpretation is that the interpreter must rely on those interpretation clues which have a high probability of being imaged on limited content photography. These clues are frequently different from those primarily used for conventional scale photography and the following techniques for small scale interpretation are based on the use of these different primary clues. These techniques are, in a sense, mental processes which guide and channel the interpreter's effort to find meaningful images on his photography. There are, in effect, four interpretation techniques useful to the interpreter: diagnostic feature analysis, pattern analysis, association analysis, and integration of any two or three of the above.

- a. Diagnostic Feature Analysis is defined as a technique of interpretation whereby an installation may be identified by recognition or detection of a minimum number of large, unlike elements which, individual or in combination, are characteristic of only one type of installation.

Most installations are composed of many different types of components which are essential to the operation of the installation. However, it is known that in many cases it is necessary to recognize only a minimum number of the components to identify the installation. If a type of installation has its own "set" of diagnostic features which, in their

normal arrangement, are characteristic and unique to that type of installation. A trained interpreter can identify it by recognizing only this minimum number of features. These diagnostic features would be selected by pre-analysis both for their validity as diagnostic features and for their probability of being recorded by a photographic system. In this light, many of the selected diagnostic features would be large components and/or these components with linear characteristics. For identification, it is not necessary for the photographic system to record the true shape of all of the diagnostic features of an installation, certain of these features need merely to be detectable. Interpretation of these detectable features is possible, in many cases, due to their characteristic arrangement. For example, if diagnostic features "A" and "B" are recognizable as to their true shape and there is a detectable "blob" in a characteristic position with reference to "A" and "B", it can be inferred to be diagnostic feature "C". The number of diagnostic features which need to be recognizable as to their true shape versus those which need only to be detectable depends upon the variability of arrangement of the features in a given type of installation.

- b. Pattern Analysis is defined as an interpretation technique whereby an installation is identified by a unique and characteristic pattern formed by similar components which are not necessarily identifiable individually.

If an installation consistently evidences a characteristic pattern and the pattern is unique, then the pattern will provide identification of the installation. A number of similar objects or groups of similar objects bearing a particular spatial relationship to one another create the pattern. Ordinarily, the spatial relationship of the pattern elements is sufficiently distinctive that only minimum information concerning size and shape of the pattern elements is needed. This illustrates the virtue of pattern analysis from a

image efficiency standpoint, that is, in most cases more detectability of the pattern elements is all that is necessary to make the technique workable.

To be identifiable through pattern analysis, an installation must exhibit a pattern which is characteristic of the installation and unique in the universe of patterns. After examination of a number of examples of an installation (pre-analysis), the pattern of one of the examples, or a simulated pattern, may be set up as normal. Most installations will exhibit patterns which vary slightly from the normal. The normal pattern must be established with indications of the limit of the variations to be expected in the spatial relationship of the pattern elements. Two installations may have pattern elements of the same magnitude and shape and similar, but not identical spatial relationship (in the mathematical sense). Unless limits are placed on the variations to be expected in the spatial relationship of the pattern elements, the two installations might be confused.

- c. Association Analysis is an interpretation technique whereby the identification of an installation is deduced from the known association of identified items outside the installation.

We know that most man-made items have a functional association with other man-made features and with their environments. Many of the associated items are more susceptible to detection and recognition than the installation itself, especially when dealing with degraded images. Progress is made by the use of this technique only when a definitive association exists and when the associated items are more easily identified than the installation.

The technique is also useful in thwarting camouflage attempts and in interpretation of photography taken through scattered clouds.

The association analysis technique does not always yield a single, positive identification, but often

does allow confinement to a small group of possibilities. With a little additional information, a final identification can often be made.

- d. Integration of Techniques is the use, in combination of any two or three of the heretofore described techniques (i.e., Diagnostic Feature Analysis, Pattern Analysis, and Association Analysis) in the identification of an installation.

A large group of installations may not be identified by the use, individually, of diagnostic feature analysis, pattern analysis, or association analysis. However, by using any two or all three of the techniques together, these installations may be identified. Even in cases where one technique alone permits identification of an installation, integration of techniques may be more rapid or more efficient. There is a general tendency for the integration technique to become relatively more useful as image quality becomes poorer, e.g., even the largest diagnostic features may be lost where image quality is poor. Thus, resort is made to an integration of techniques which calls upon pattern and/or association analysis for additional information.

It is recommended that a minimum image quality requirement for various PIC functions be established.

Upon establishing levels of minimum image qualities and use, determination for justifying automatic handling systems may be accomplished.

AUTOMATIC HANDLING SYSTEMS

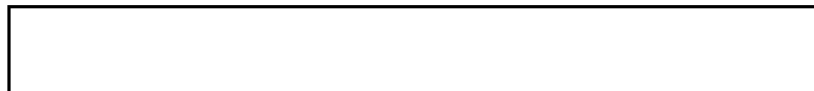
REQUIREMENT FOR THE PIC

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Special Projects Division

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CONCLUSION

Many articles have been written stating the urgent need for automation. The justification is a result of the scarcity of computers and a significantly increasing PIC workload.

This report justifies the types of automation systems required which will meet the PIC objectives.

1. Image Requirements

One of the most important roles played in the PIC is played by the Photo Interpreter and it is basically his need which dictates the high image quality automation data handling requirement.

The type and quality of photo image the PIC requires depends to a great extent upon the functions of the PIC as well as various personnel abilities. Regardless of the automation handling system designed, it must satisfy image quality requirements. It is therefore necessary to define the image quality requirements in order to justify any handling system.

The image quality required for the PIC ranges from the highest level which may be considered as the actual real image, down to the lowest level of image quality which may be considered as a mere verbal or written document interpreting a mental image.

Name of Image Quantity Classifi- cation	Image Source Descrip- tion	Name of Image Degradation Rating	Image Cost Rating	Image Quality Elements										Human Description
				Sensing Element	Atmosphere or Environment	Equipment	Film Quality	Reproduction	Processing	Miniaturizing	Electronic Conversion	Graphic Conversion	Artist Conversion	
Ultimate Image	Actual Scene	1. None	1st Highest in cost per image	x	x									
Mirror Image	Transmitted Actual Image	2. Negligible	2nd	x	x	x								
Conventional Image	Film or Photo Plate Image	3. Measurable	3rd	x	x	x	x	x	x					
Transformed Image	Microfilm or Electronic Recorded Image	4. Noticeable	4th	x	x	x	x	x	x	x				
Graphic Image	Plotted or Artistic Representative Image	5. Obvious	5th	x	x	x	x	x	x	x	x	x	x	
Interpreted Image	Verbal or Written Description of the Image	6. Highly Degraded	6th Lowest in Cost per image	x	x	x	x	x	x	x	x	x	x	x

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IMAGE QUALITY USE APPLICATIONS SUMMARY

Degree of Image Quality Classification	Functional Use Applications								Mimiccard System Use Application	Industrial Automatic Systems Use Application
	R & D	Photogrammetry	Scam	Search	Operation Support	Exploitation	Data Research	Reporting		
Ultimate Image	x	.	.	x	x	x	.	.		
Minor Image	x	.	.	x	x	x	.	.		
Conventional Image	x	xxx	xxx	xx	x	x	x	x		
Transformed Image	x	x	x	xxx	xx	x	xx	x	x	x
Graphic Image	x	xx	x	x	xxx	xx	xx	xx		x
Interpreted Image	x	x	x	x	xx	xx	xxx	xxx		x

NOTES:

1. **xxx** Significant Amount of Use
2. **xx** Normal Amount of Use
3. **x** Minor Amount of Use

**Significant amount of use justifies automation handling.

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CONCLUSION

In conclusion, the present Minicard system will not satisfy a significant percentage of scan, search and photogrammetric system requirements. Although it is a justified automatic handling system inasmuch as it does significantly satisfy other functional requirements in the areas of reporting, correlation, data research, etc. The areas of systems design effort expended in the various automatic handling systems areas should be compatible with functional use and importance.

Inasmuch as larger amounts of film handling in the Conventional Image Quality level are contemplated, it is important that significant amount of systems effort be stressed in the area of automatic handling of Conventional Image Quality film. It is not as important to stress systems effort in the area of automatic handling of Transformed Image Quality or lower image quality areas inasmuch as a significant amount of outside effort has been and is being spent in this area.

Conventional Image Quality film will require automatic handling which in turn, will require protective provisions by fluid and/or electronic means in order to maintain the quality level.

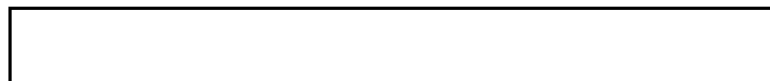
Conventional, Transformed, Graphic, and Interpreted Image Quality automatic handling systems will require proper integration in order to avoid efficiency penalties. This integration requirement, which also includes NPIC, is justified due to the contemplated increase in workload.

**PHOTO INTERPRETATION BY
MIRROR IMAGE QUALITY CONCEPT**

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There are critical occasions where the highest image quality is required in high levels of photo interpretation where an almost infinite amount of detail is required in order to satisfy the intelligence needs.

This report describes a conceptual solution in possibly meeting the requirement for obtaining and handling "mirror quality images". "Mirror image quality" is considered as the highest image quality, second only to the actual viewing of an item.

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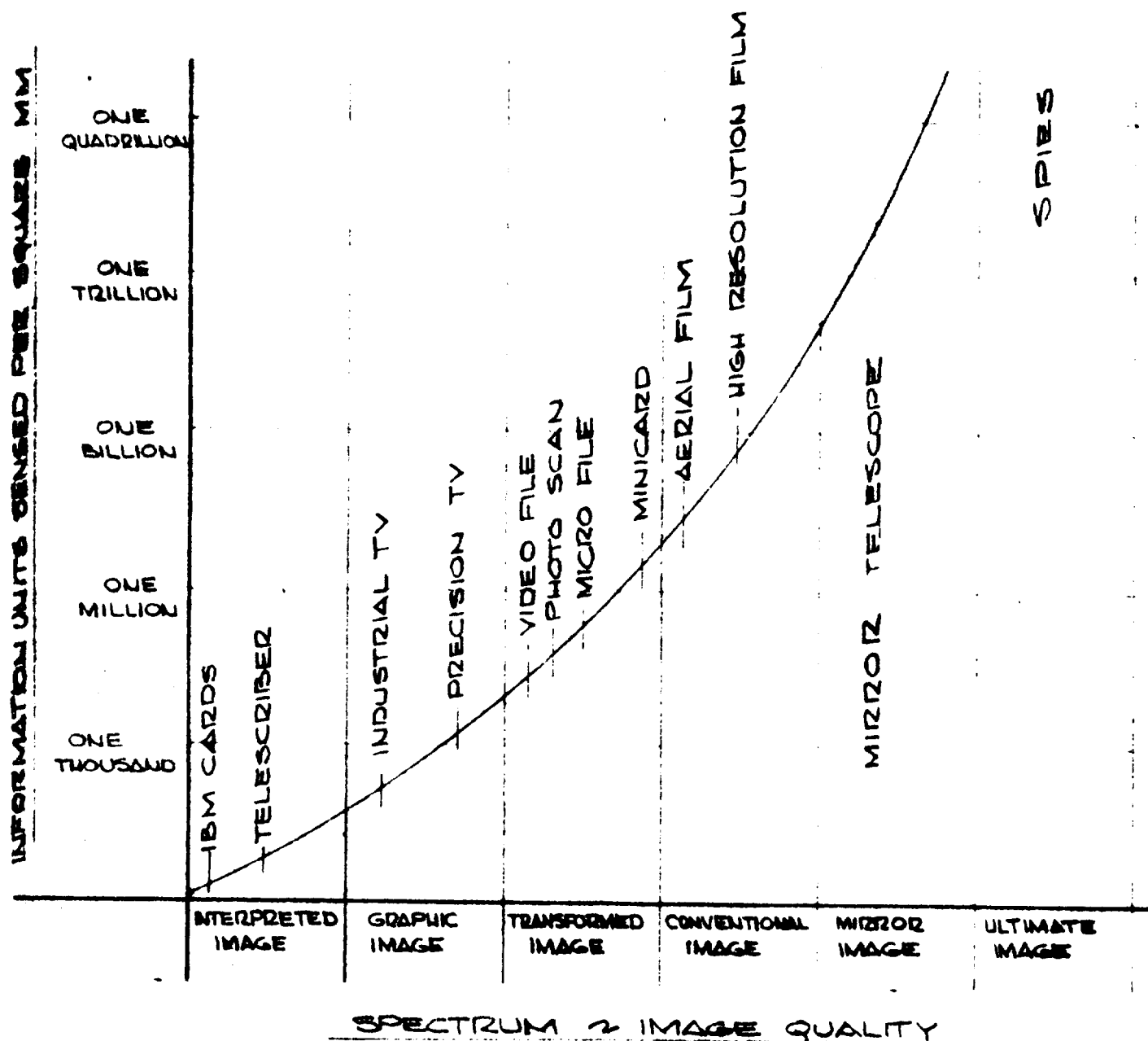
Mirror image quality techniques are required when conventional image quality photo interpretation fails even under all enhancement advantages due to insufficient amount of detailed information recorded.

A costly problem in obtaining mirror image quality is mainly in the image acquisition area. Upon acquisition, handling techniques are required to maintain quality.

At present, photo plates have capabilities of recording 2500 lines per mm. and 300 tone shades of gray, thus making a total amount of 1,875,000,000 information units per square mm. of black and white continuous tone recording capability. This high quality is pushing the state of the art; however, even the highest photo plate quality may be unacceptable for "mirror image quality" because photo processing is too great a degradation source.

It is known that the state of the art now possesses high quality mirrors which degrade images to a negligible amount, thus allowing an almost infinite amount of information units per square mm. So small is the degradation that even color is negligibly degraded.

The United States plans to send up four stationary man-made satellites for navigational and communication purposes. It may be advisable to investigate this area to determine the feasibility of incorporating controllable mirrors on these stationary man-made satellites. Then, by telescopic means, direct remote viewing may take place.



NOTES:

1. INFORMATION UNITS CAPABLE OF BEING SENSED ARE THE PRODUCT OF RESOLUTION X DETECTABLE FACTORS
2. INFORMATION UNITS CAPABLE OF BEING STORED ARE ONLY A FUNCTION OF RESOLUTION.

IMAGE QUALITY VS INFORMATION UNIT CONTENT

FIGURE A

RECOMMENDATION

It is proposed that an investigation be made to determine the feasibility of "mirror image quality" using the scheduled stationary satellites as a space platform.

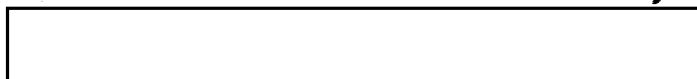
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PAST-PRESENT-FUTURE
OF
INTELLIGENCE ACQUISITION

Prepared By

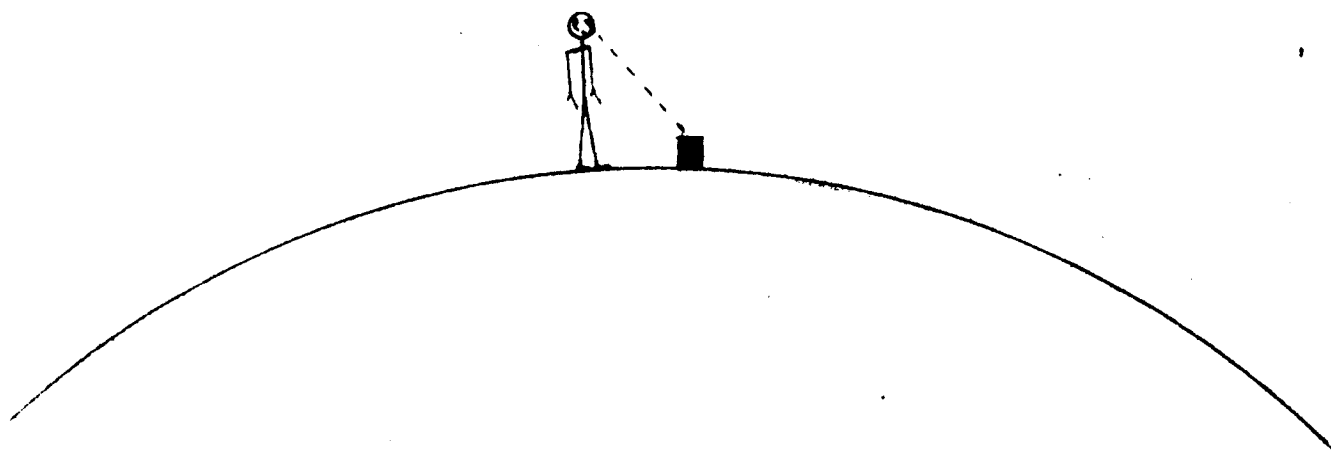
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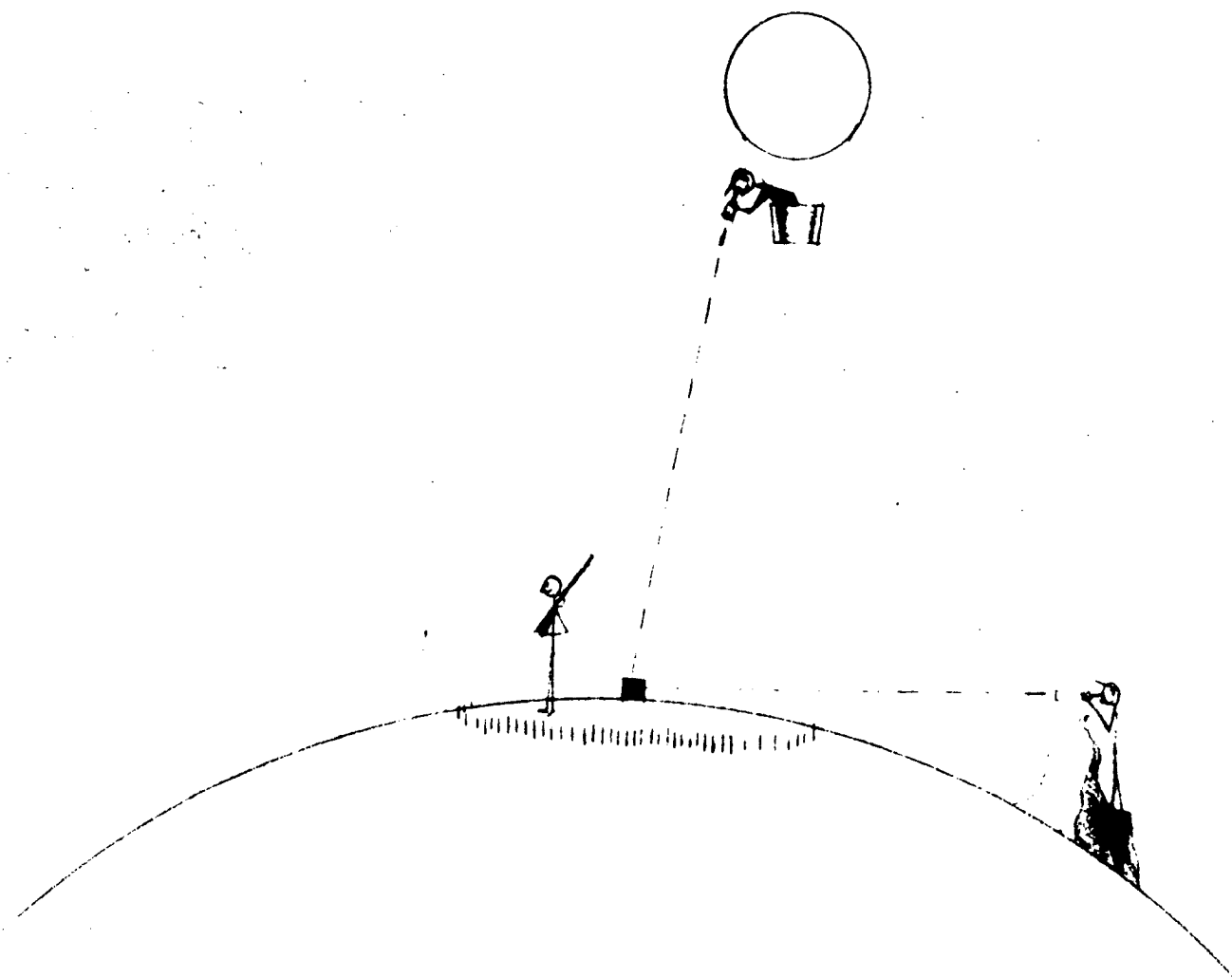


April 28, 1961

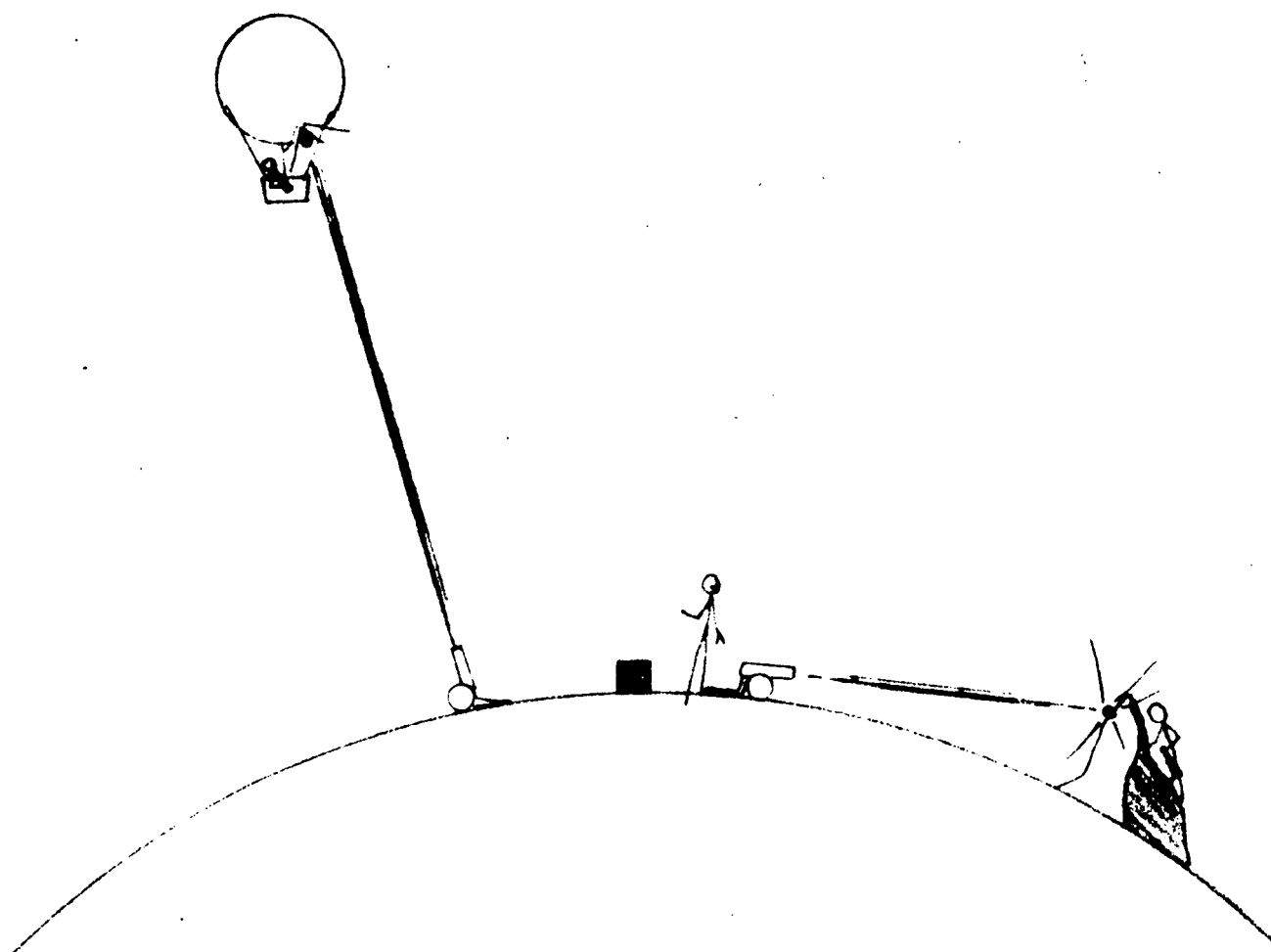
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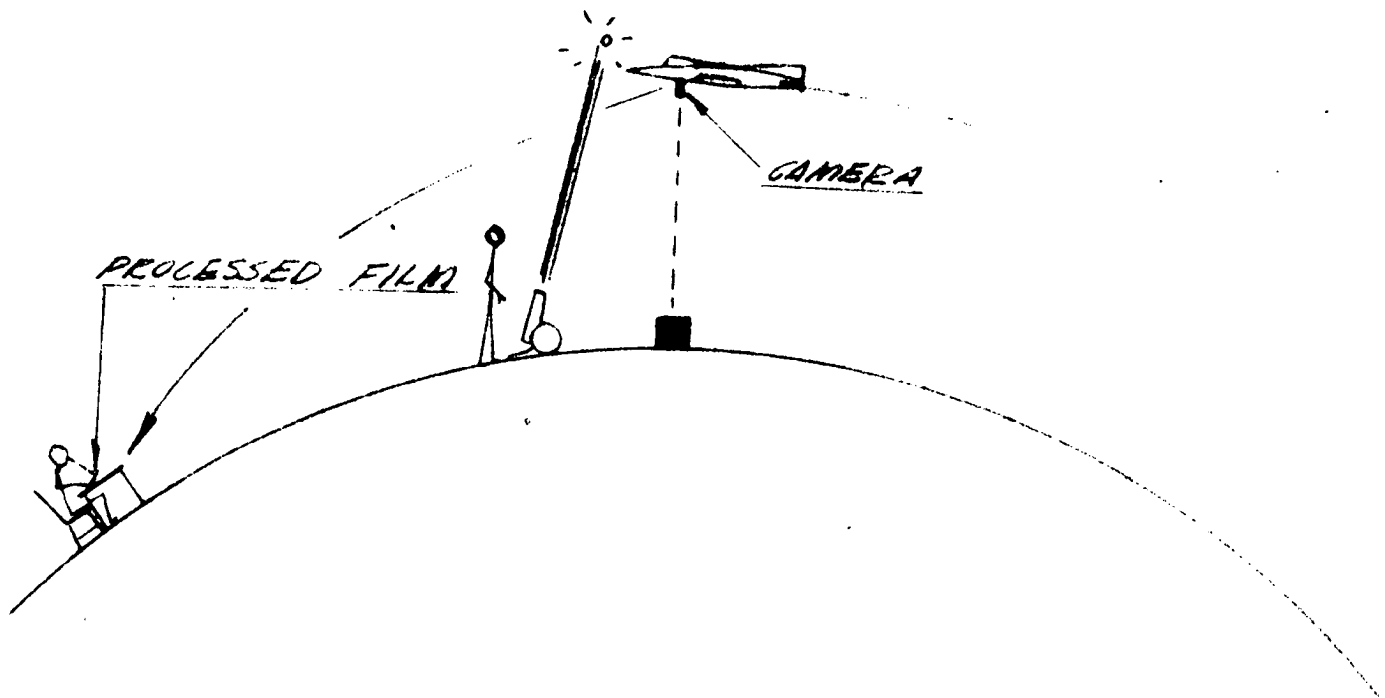
In the past intelligence acquisition took place by observing the actual object under consideration. The image quality was very high with little or no image degradation.



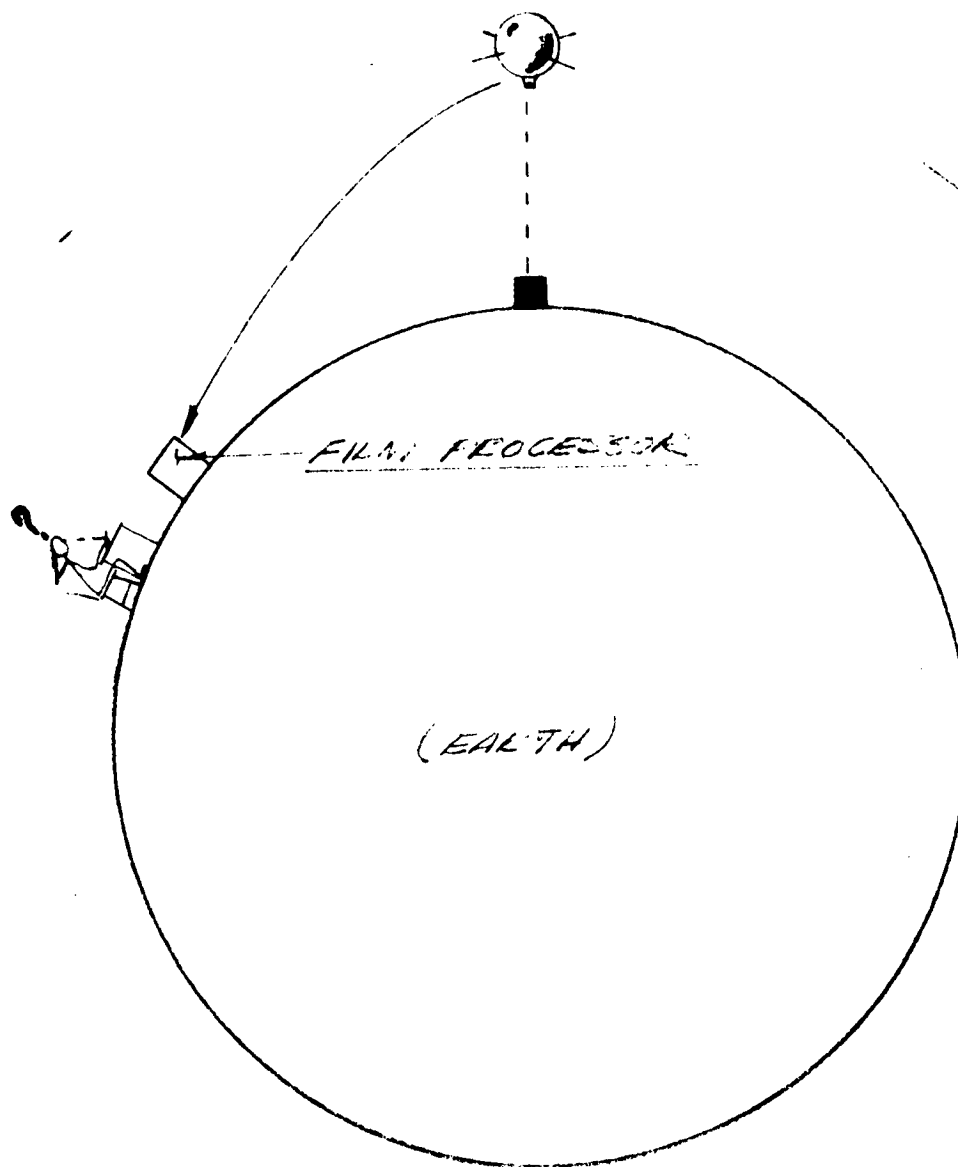
As resistance to observation took place intelligence acquisition from remote areas by means of direct viewing aids became necessary.



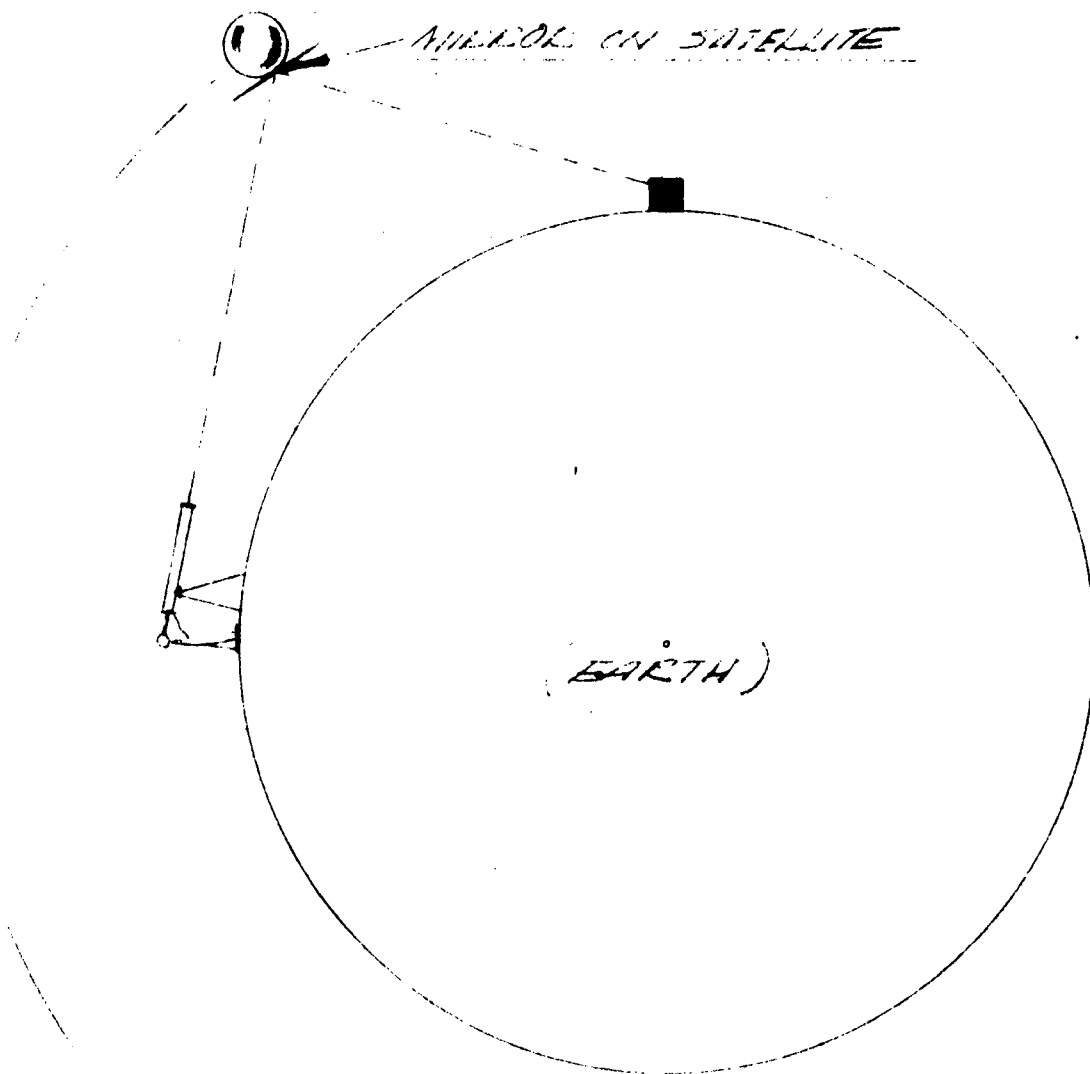
Resistance to direct intelligence acquisition improved, causing other and improved means of intelligence acquisition. As a result photo intelligence was originated.



As resistance improved photo intelligence methods also improved.



You too may recall that resistance improved to such a point that significant photo intelligence improvements are required.



Recall man-made **Satellite** scheduled for navigational and communications purposes will appear stationary, approximately 25,000 miles from the surface of the earth in an orbital direction compatible with the rotation of the earth.

Improvements in the future may again call for direct intelligence acquisition methods.